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Baseline Study of the Relationship Between Green Space and Age

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Abstract

Current research on green space and human health is spread among many academic disciplines and is growing. To aid researchers and local governments in understanding the relationship between the two, this study presents a baseline analysis of the spatial relationship between green space and age. It considers how a city's population is distributed around green space and looks at spatial and statistical patterns related to age and location. This study identifies a gap in current research and looks at green space and age in a geographic manner. The findings of this literature review and analysis provide researchers with another way to visualize and analyze the benefits of green space to human health.

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Introduction

Modern science and technology have found ways to greatly improve the quality and length of an individual's life. With these improvements, people are living longer and the world population is growing at a staggering rate. One trend that has developed as a result of this has been a migration of people from rural areas to the urban environment. It is expected that by 2030 almost five billion people will live in urban areas, which would amount to 60% of the projected global population of 8.3 billion (Venugopal et al., 2010). As a direct consequence of such accelerated urban growth, there is increasing pressure on urban areas leading to the green space in cities being diminished even though they are the lungs of cities (Gupta 2011). The migration to urban environments increases the value of land within a city and requires a change in the planning and development of cities for future population increase.

Within a city, there are a number of areas that are utilized by people for recreational purposes called "green space". Green space as defined in the Merriam-Webster dictionary, which can also be called; open space, greenway or green belt, is community space consisting of land rather than buildings. Green space areas are under constant scrutiny because cities can develop and utilize this land to provide much needed residential or commercial property within a city. Because of increasing urbanization, combined with a spatial planning policy of densification, more people face the prospect of living in less green residential environments (Groenewegen 2006). Research shows that there is a definite link between the natural environment and the physical and mental well-being of people. There are numerous studies showing how the physical, psychological and social well-being of people can be improved by being exposed to green space.

This study seeks to understand if there is a spatial relationship between green space and age within a city's population. Use of secondary data acquired from the City of Odessa, Texas, Provo, Utah, and the U.S. Census Bureau will provide an unbiased base to begin. In many of the studies discusses below, it is assumed that there is a positive relationship between age and green space. This study will focus on determining if there is an identifiable spatial relationship between green space and age using area, proximity, and statistical analysis.

Literature Review

There is a relatively small academic community that researches and analyzes the relationship between human health and green space. This group is made up of academics from a multitude of scientific disciplines, such as geography, psychology, sociology, medical, and environmental. Frumpkin (2002) provides a good example of the many variables that should be considered when looking at green space and human health. He discussed the relationship between sprawl and health based on eight considerations: air pollution, heat, physical activity patterns, motor vehicle crashes, pedestrian injuries and fatalities, water quality and quantity, mental health, and social capital. The data from his study shows both health benefits and health costs. As is true for most public health hazards, the adverse impacts of sprawl do not fall equally across the population, and those who are most affected deserve special attention. While many studies touch on various aspects of human health and the relationship to green space, no studies appear to have focused on establishing a definitive spatial relationship between the two.

Most of the research for this study concluded that green space provides a positive impact on human health. It should be noted that there is existing work suggesting that in some cases the amount of green space in people's living environment has little influence on people's level of physical activity (Maas 2008). Additionally, Maheswaren (2011) found that establishing a causal relationship between green spaces and health was difficult and reviews done so far have been based on weak studies. Richardson (2010) found that public green space availability in New Zealand may not be as important a determinant of health as found elsewhere. Importantly, these findings emphasize that green space and health relationships are likely to vary on a nation-by-nation basis. Previous research in public health has not always been conceptually precise about the specific dimension of green space that matters, or the mechanism through which it has an effect on physical activity. It is important to identify dimensions of green space that are more relevant to physical activity participation in order to develop objective measures that can be used to help practitioners make informed decisions about creating activity-friendly green spaces (Leslie 2010).

Some recent work has looked more generally at how green space relates to health. Bedimo-Rung (2005), noted that few studies have explicitly investigated the impact of park-based leisure activity levels on the physical health of park users. Townsend (2006) looked at how engaging in environmental activities affected general health. The findings from a study by Payne (2005) suggest that people who have parks within walking distance use them more frequently and are in better health than those without parks within walking distance. Even some of the products produced by green space have also been found to have a positive impact on human health. Nowak (2006) analyzed the effect urban forests have on alleviating air pollution. Yamada (2006) found that sound from different types of forest had therapeutic value to an individual's health and well-being. Simply living in neighborhoods with more green spaces was also determined to improve health over those without green spaces (De Vries 2003). Ulrich (1984) focused on the aesthetic, emotional and physiological response to visual landscapes and observed a faster recovery among surgical patients who viewed trees from the hospital window. Access to green areas were also thought to play a role, but Nielsen (2007) determined that benefits of greenery area only partly derived from visiting such areas.

There have been a number of studies that have looked at the health benefits of having visual exposure to green space. Starting with Ulrich (1985), visual encounters with vegetation may be greatest for individuals experiencing stress or anxiety. Recent research demonstrates that responses to trees and other vegetation can be linked directly to health, and in turn related to economic benefits of visual quality. Kaplan (1993) took this further showing that given the availability of a window, it also matters what can be seen. If all that can be seen are built elements, even if they do not obstruct natural light or reduce access, the psychological benefits are not promoted. The elements of nature that seem to make such a strong difference need not be any more than a few trees, some landscaping, or some signs of vegetation. The presence of other buildings or parking lots does not seem to be a problem, as long as the natural world is there too. More recently, Hartig (2003) noted that regular access to restorative environments can interrupt processes that negatively affect health and well-being in the short- and long-term. For urban populations in particular, easy pedestrian and visual access to natural settings can produce preventive benefits.

Other studies suggest that exposure to environmental areas can have a positive influence on the psychological well-being of individuals (Frumkin 2001). Another interesting implication is that restorative effects can be realized in a range of natural settings that includes urban parks and wilderness areas (Hartig 1991). The amount of green space in the living environment is not only related to people's health condition but is also positively related to people's feelings of loneliness and shortage of social support, especially for children, elderly, and people with a lower economic status. Additionally, both feelings of loneliness and shortage of social support partially mediated between the relation between green space and health (Maas 2008).

More research has been conducted from a medical standpoint that the other scientific disciplines identified. Many of these studies focus on some form of exercise and green space and how proximity to these areas improves human health. Cohen (2007) noted that most people who exercised did so in their local park, so the frequency of exercise and frequency of park use are both associated with park proximity. Verheij (1996) researched this further and determined that individual characteristics have an effect on whether someone experiences positive and negative environmental aspect as it relates to health. Nielsen (2006) has a different view, stating that the use of green areas cannot explain the effects of green areas on the health indicators. It is suggested that the benefits of greenery is only partly derived from "formal visits" in such areas. Even children with better access to parks and recreational resources are considered to be less likely to experience weight increase (Wolch 2010). Hansmann (2007) found that physical activities performed in forests or outdoor areas improved the health condition of people. Maas (2006) investigated this even further looking at the relation between the amount of green space in people's living environment and their perceived general health. The findings of that study indicate that a positive relationship did exist within a 1km radius from an individual's residence. Related to that idea, Sugiyama (2008) studied the effect that the quality of open space has on walking and active lifestyles of older people. Takano (2002) had similar findings showing that the factor of walk-able green streets and spaces near the residence significantly and positively influenced the five year survival of senior citizens independent of a person's age, sex, marital status, attitude toward their own community, and socioeconomic status. Kessel (2009) noted that the health benefits of using a green space for walking or exercising are well recognized. However, whether people choose to use local green space may be determined by a variety of factors. In a carefully controlled laboratory simulation, Pretty (2005) noted that green exercise is more effective than exercise alone in improving measures relevant to cardiovascular and mental health.

There have been few studies on life expectancy in general, let alone focusing on issues at the level of a city or metropolitan area. Shaw (2005) studied issues affecting life expectancy of people in developed countries. That study revealed that consumption of pharmaceutical products can increase life expectancy. A study conducted by Sufian (1989) looked at developing countries and was able to determine that literacy rate, daily caloric consumption, and family planning have an effect on life expectancy. Another report by Barlow (1999) concluded that at a national level, location, education, fertility, and income level area directly related to life expectancy. Interestingly, one common factor in many of these studies was education or literacy rate. In another study related to mortality, gender was determined to be a differentiator. Richardson (2010) noted that male cardiovascular disease and respiratory disease mortality rates decreased with increasing green space, but no significant associations were found for women. No protective associations were observed between green space and lung cancer mortality or self-reported limiting long-term illness for either men or women. Finally, Mitchell (2008) noted that an independent association between residence in the most green areas and decreased rates for all-cause and circulatory mortality

Design and Implementation

Study area

Two cities from the central portion of the United States (Odessa, Texas and Provo, Utah) were selected for this study. Odessa, Texas and Provo, Utah were randomly selected and then chosen based on their reported population (close to 100,000) and availability of suitable GIS data. The map (Figure 1) below shows their location.

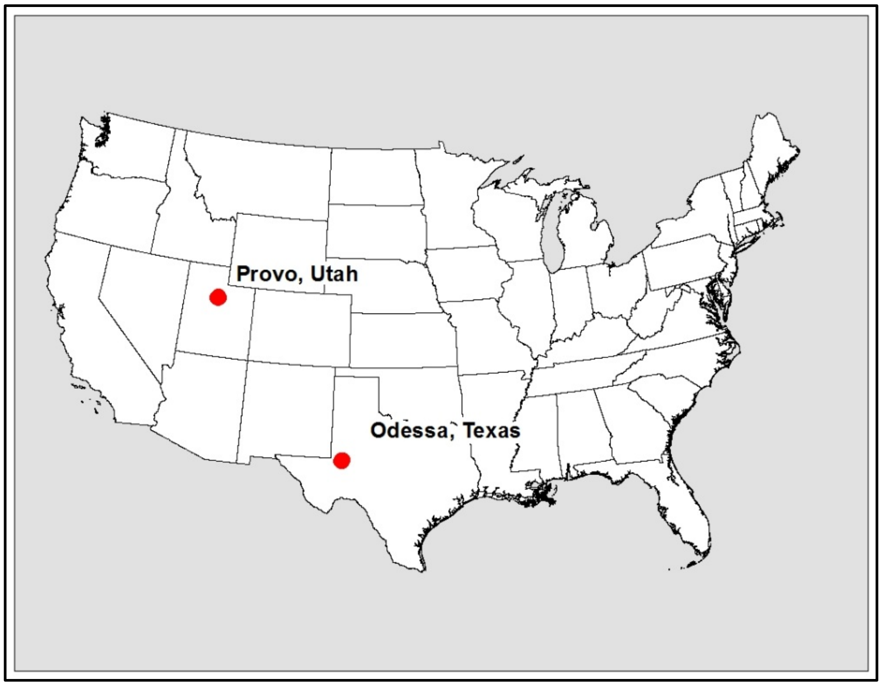

Figure 1. Study area (Odessa, Texas and Provo, Utah) locations

The City of Odessa, Texas was the first city chosen for this study. Odessa is located in west Texas and has an economy that is driven primarily by the oil industry. According to the U.S. Census, in 2011 the City of Odessa had an estimated population of 102,106 and occupied a land area of approximately 41.95 square miles. As mentioned above, Odessa is primarily an “oil” town and the economy is very dependent on that. The city is making attempts to diversify and expand into other business areas in order to ease their dependence on the oil industry. One major area of investment is in wind energy.

Provo, Utah was the second city chosen for this study. Provo is located just south of Salt Lake City and is the third-largest city in Utah. The U.S. Census estimates Provo had a population of 115,321 in 2011 and occupied an area of approximately 41.67 square miles. Provo is home to Brigham Young University, one of the largest private higher education institutions in the United States. Economically, Provo is a focal point for technology in the state of Utah. Overall, Provo is a diversified city that is not reliant upon one industry sector.

This study will focus specifically on the City of Odessa, Texas and the City of Provo, Utah and not the metropolitan statistical areas. To ensure that the data used in this study is the most accurate and up to date data set possible, authoritative data will be acquired directly from the each city's GIS program.

Methods

The Data for this study was collected from three separate data sources. First, data was collected for the City of Odessa by mining data from the City website. Suitable GIS data was located and then downloaded in Esri's Shapefile format from the GIS Downloads webpage (http://www.odessa-tx.gov/index.aspx?page=354) located in the GIS Division, which was found in the Public Works Department of the City of Odessa. Data for the City of Provo was not available on the City website, but the city did have a large number of maps available showing the extent of GIS data used by the city. GIS data for the City of Provo was attained by coordinating directly with the City's GIS department. This included working with a City GIS Analyst to determine what layers could be used and would be appropriate for the study.

The GIS Analyst pulled the appropriate data and delivered the data in Esri's Shapefile format via email.

Census data was mined from various applications and web services from the U.S. Census Bureau website (http://www.census.gov/). The U.S. Census Bureau provides data related to population, economic activities, and geographic areas in the United States. From the Census Bureau TIGER/Line Shapefiles webpage (http://www.census.gov/geo/maps-data/data/tiger-line.html) census data and boundary data for the year 2010 and 200 was acquired for the entire state of Texas and Utah. This data contained information providing a spatial location for census blocks and the Geo ID. The TIGER/Line data does not provide actual demographic data. To obtain that, tabular census data for the year 2010 and 2000 was acquired from the U.S. Census Bureau's FTP website (http://www2.census.gov/) for the entire state of Texas and Utah.

Green space

Because there is no nationwide standard or policy for layers maintained by a city and city GIS departments have differing requirement, budgets, and resource, the number of layers and name of each layer can differ. Green space is not typically used as a standalone data source in GIS systems and can vary significantly in definition. For the purpose of this study, only data readily available from the city will be used. Green space is the conglomeration of many different layers that represent different green space areas. Common examples of layers considered Green space are:

- Parks
- Recreational fields (soccer, football, baseball, etc.)
- Wooded areas (including forests)
- Trails
- Golf Courses
- Greenways and green belts
- Botanical gardens
- Cemeteries
- Vacant lots

To prepare the green space data for analysis, all layers identified as being part of the green space data layer for each city were aggregated into one layer by utilizing the dissolve feature in Esri ArcGIS Desktop.

Census data

Data from the U.S. Census Bureau was downloaded in two parts; demographic data was downloaded in tabular format, while the spatial representation (geographic location) data was downloaded in the form of TIGER/Line Shapefiles. Preparing the 2000 and 2010 census datasets required completing a number of steps outlined below.

- Download data from census bureau FTP website
    - Microsoft Access template database template
    - Two text files of demographic data

- Import demographic data into the Microsoft Access template database
- Create attribute (Geo ID) to link demographic data to TIGER/Line data
- Query demographic data using applicable Geo ID
- Export query to Microsoft Excel file
- Create Full Geo ID (conglomeration of ID's for the State, County, Tract, and Block group)
- Link demographic data in the Microsoft Excel file to TIGER/Line Shapefile using Geo ID.

Because of changes made to the template database after the original release of the census data, extra steps were taken in order to import the demographic data into the Microsoft Access template database. The data downloaded from the Census Bureau FTP website have not been updated to reflect changes made in the template Access database. In order to import the data properly, it had to be pre-processed.

Pre-processing the segments listed with "mod" required the use of text editing software that has a find and replace function. In order to prepare these segments for use with the Access shell it was necessary to "Find" the data contained within the first four fields of the segment and "Replace" them with nothing. The result was a segment that begins with the field LOGRECNO rather than FILEID. These segments can be readily identified within the Access database by the appending of the text "mod" to both the table example and the import script's name. This Process took over two hours for Utah and over 18 hours for Texas. The steps taken to prepare the census data is outline below:

- Open the segment WordPad
- On the Edit menu, select Replace
- In the “Find what:” entry box type in “SF1ST,<ST>,000,<Segment>,”
    - <ST> = two letter abbreviation for the state (TX or UT)
    - <Segment> = two digit segment number for the segment you are preparing (12).
- It is important that the final comma is included in the string being replaced
- Leave the “Replace with:” field blank
- Click the Replace All button.
    - This may take some time to run as it is processing the entire segment.
- Once the complete, click the Cancel button to close the Find/Replace window and then save the file

At the completion of the last step, the segment is ready. The prepared census data then needed to be modified to create the age groups that were used in this study. To do this, the tabular census data was edited in Microsoft Excel to merge multiple attribute fields together, creating the final age brackets. For this study age groups were defined as; 19 and under, 20 to 64, and 65 and over.

The data was then joined to the TIGER data using ArcGIS Desktop for visualization and to enable spatial analysis. Prior to performing any spatial analysis, the census data was compared to the administrative boundary for each city. Any data that was determined to be outside of the administrative area was removed from consideration for this study. The maps below (Figures 1 and 3) are examples of the census data for 2010 after it has been prepared for use in this study.

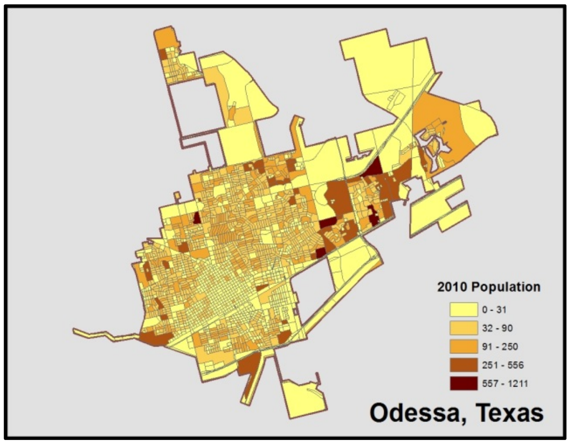

Figure 2. City of Odessa, Texas

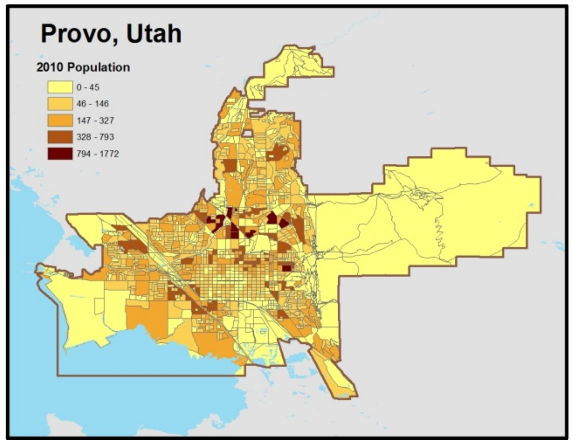

Figure 3. City of Provo, Utah

To prepare the census datasets for geographic distribution analysis, the combined TIGER shapefile and tabular census data was converted from a polygon format to a point format using Esri's conversion tool "Feature to Point". The Feature to Point tool creates a point from a representative polygon located at the centroid of the polygon.

City Maps

In order to visualize the results and "frame" the study area, a base map for each city map was created. The map for each city contains basic information for each city displaying features typically associated with a map. Some of these feature are: buildings, roads, administrative boundary, water bodies (lakes and rivers), and railroads. Below is the map (Figures 4 and 5) for each city.

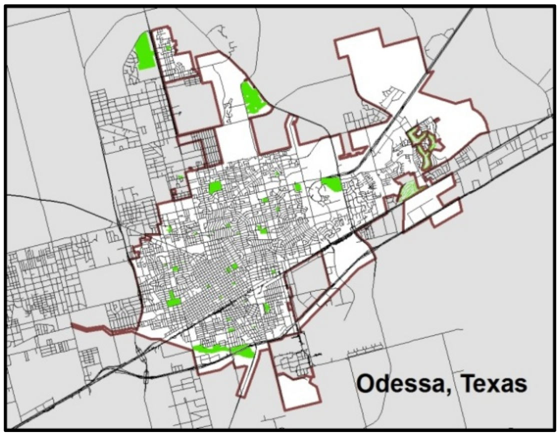

Figure 4. Odessa, Texas

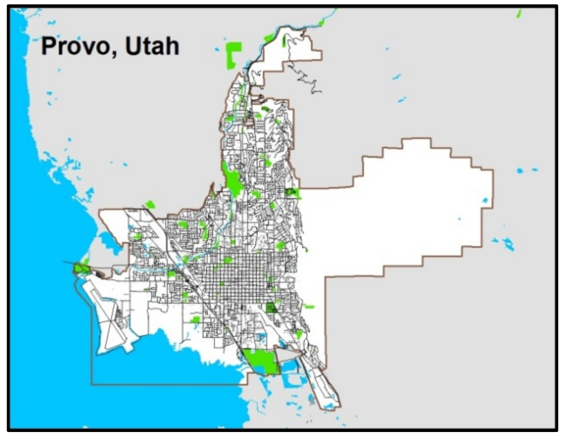

Figure 5. Provo, Utah

Analysis

City and green space area

By utilizing Esri's geographical information system (GIS) software, ArcGIS, green space data and age variables from census data were compared and analyzed. Calculation of the area of each City and total green space area in acres was completed using the statistics tool in Esri's ArcMap then converted to Square feet. Total population was determined by adding up the total population of each of the block groups located within each city's administrative boundary. The percentage of the city that is green space was then determined by dividing the total green space acres by the city area. Green space per person was then calculated by dividing total acres by total population.

Visual Patterns

Next, the data was investigated to identify any potential patterns. First, the green space data layer was laid over the census data layer to perform an initial identification of spatial trends and to identify potential outliers and errors for each city, age group, and year. This was also a visual quality check (QC) of the datasets that that ensured the data preparation steps were completed properly. The maps below (Figures 6 through 13) depict the census data and green space data for Odessa, Texas from the 2010 and 2000 Census.

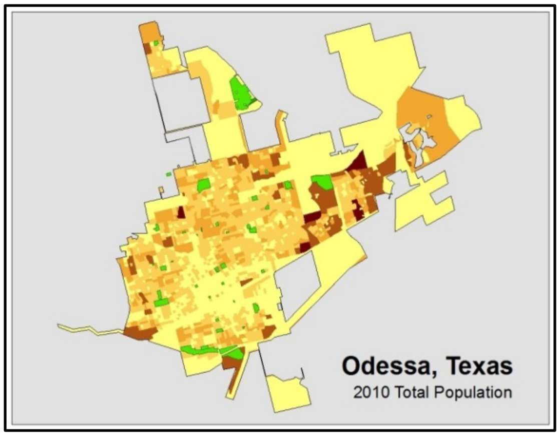

Figure 6. Odessa, Texas
2010 Total Population

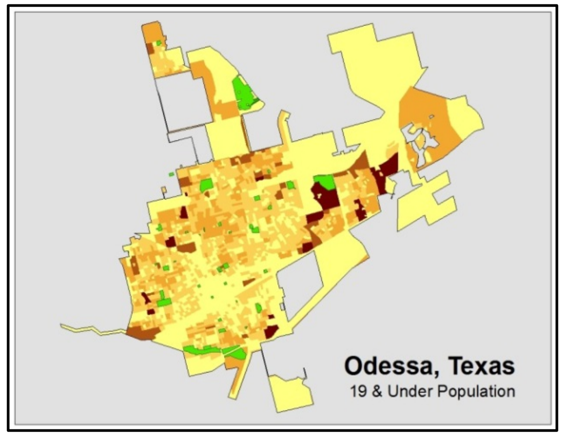

Figure 7. Odessa, Texas
2010 19 & Under Population

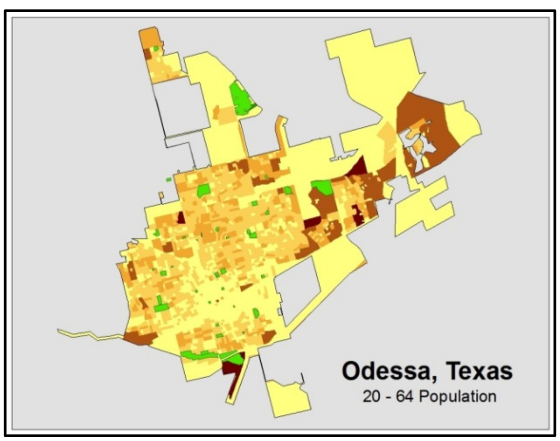

Figure 8. Odessa, Texas
2010 20 to 64 Population

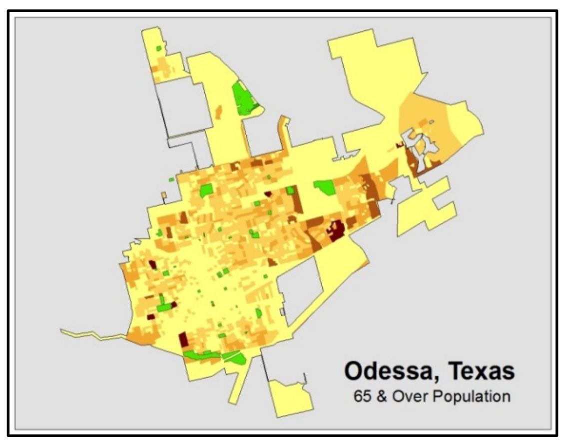

Figure 9. Odessa, Texas
2010 65 & Over Population

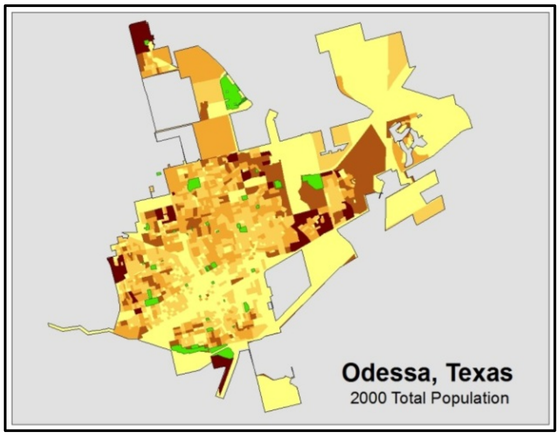

Figure 10. Odessa, Texas
2000 Total Population

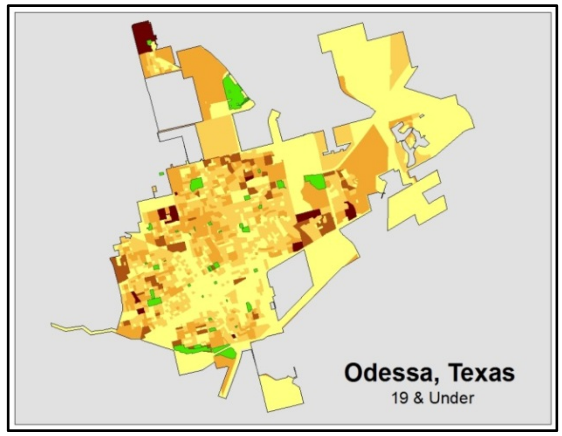

Figure 11.Odessa, Texas
2000 19 & Under Population

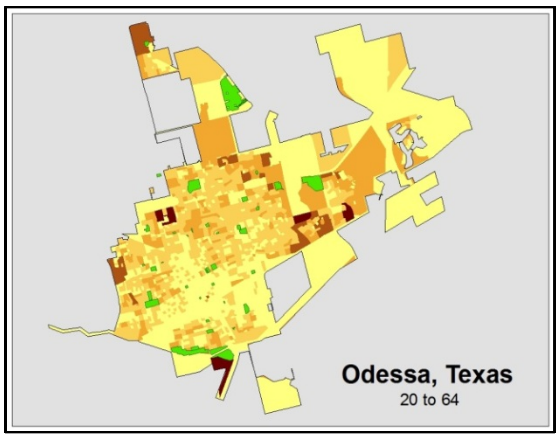

Figure 12. Odessa, Texas
2000 20 to 64 Population

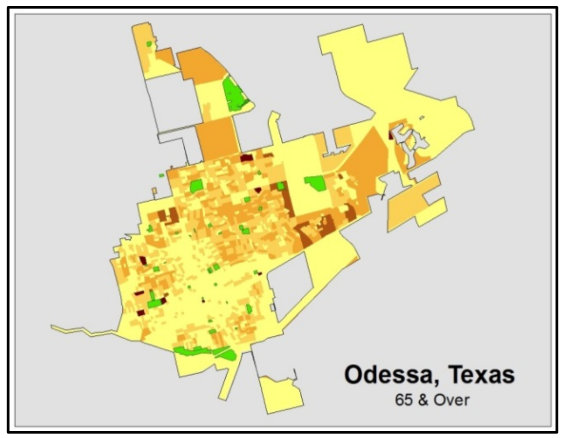

Figure 13. Odessa, Texas
2000 65 & Over Population

The following maps (Figures 14 through 21) depict the census data and green space data for Provo, Utah from the 2010 and 2000 Census.

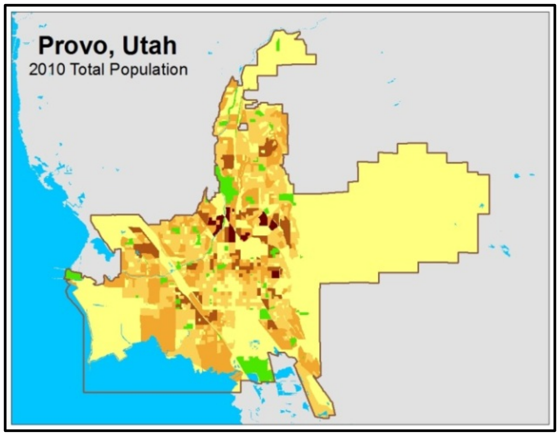

Figure 14. Provo, Utah
2010 Total Population

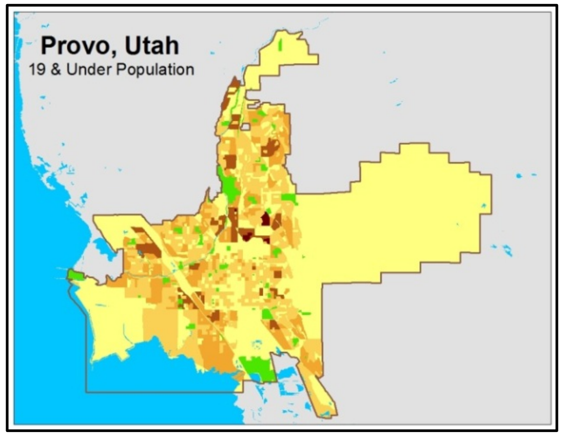

Figure 15. Provo, Utah
2010 19 & Under Population

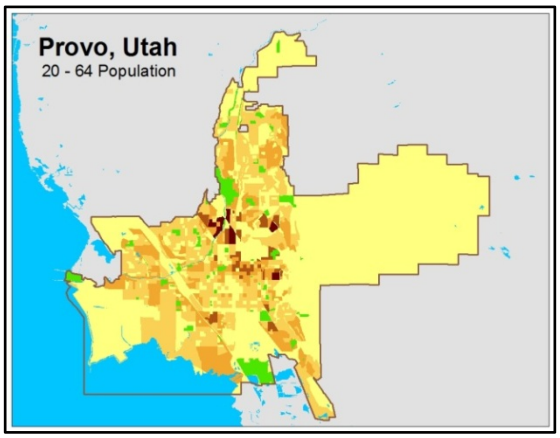

Figure 16. Provo, Utah
2010 20 - 64 Population

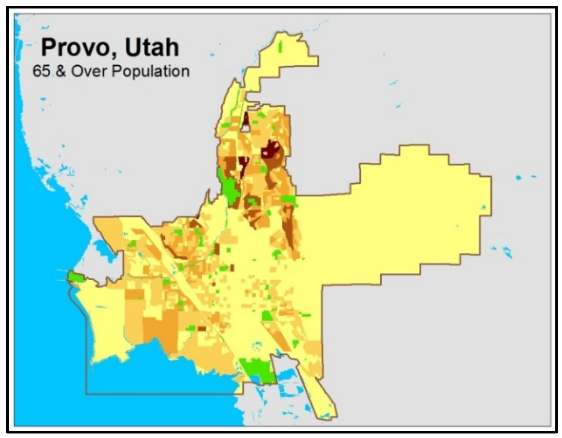

Figure 17. Provo, Utah
2010 65 & Over Population

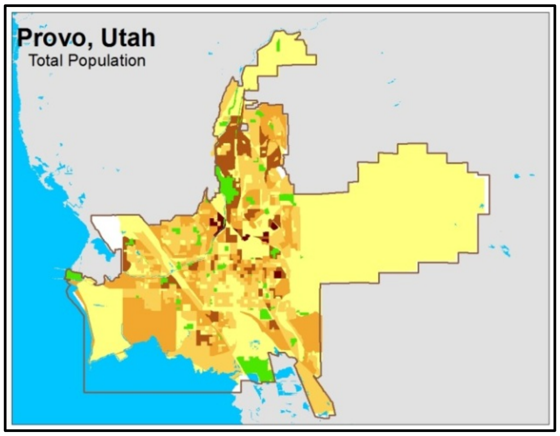

Figure 18. Provo, Utah
2000 Total Population

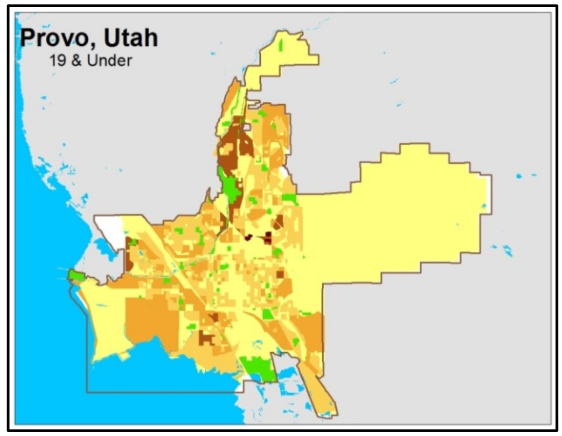

Figure 19. Provo, Utah 2000
19 & Under Population

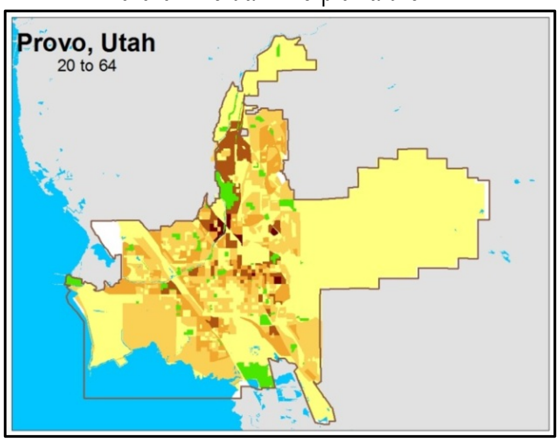

Figure 20. Provo, Utah
2000 20 to 64 Population

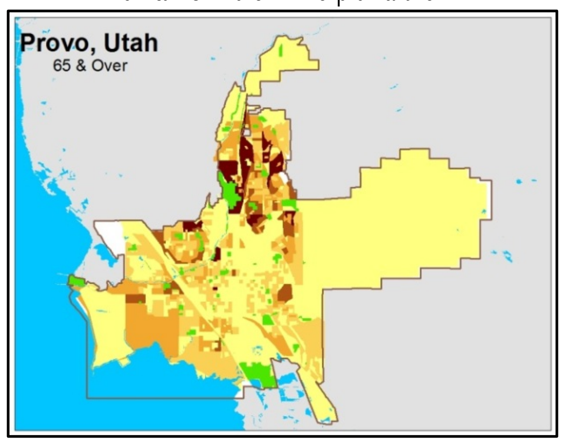

Figure 21. Provo, Utah 2000
65 & Over Population

Cluster Analysis

Three advanced spatial analysis techniques were then used to further analyze the data. First, a cluster analysis was performed on each dataset to identify any potential areas where groups of similarly aged individuals were located in relation to green space. As defined by Esri, Cluster Analysis is a statistical classification technique for dividing a population into relatively homogeneous groups. The similarities between members belonging to a class, or cluster, are high; while similarities between members belonging to different clusters are low. Cluster analysis is frequently used in market analysis for consumer segmentation and locating customers, but it is also applied to other fields.

The Cluster analysis utilized for this study was the Anselin Local Moran's I method. This method identifies clusters with similar values by calculating a Moran's I value and a Z score. A Z score is a value that represents the statistical significance of the computed index value. A positive I value indicates that the feature is surrounded by features with similar values. A negative value for I indicates that the feature is surrounded by features with dissimilar values (Mitchell 2005).

Directional Distribution

The next analysis method was used to identify possible directional trends in the datasets. The method chosen for this process was Esri's Directional Distribution (standard deviational ellipse). Directional Distribution is considered a common way of measuring trends in a dataset by calculating the standard distance in the x and y directions. The resulting ellipse is referred to as the standard deviational ellipse. The ellipse allows you to see if the distribution of features is elongated and hence has a particular orientation. Calculating the standard deviational ellipse makes visual trends clear and provides scientific reasoning rather than personal judgment (Mitchell 2005).

The Esri Directional Distribution tool creates a new feature class containing an elliptical polygon centered on the mean center for all features (or for all cases when a value is specified for Case Field). The attribute values for these output ellipse polygons include two standard distances (long and short axes); the orientation of the ellipse; and the case field, if specified. The orientation represents the rotation of the long axis measured clockwise from noon. You can also specify the number of standard deviations to represent (1, 2, or 3). When the features have a spatially normal distribution (meaning they are densest in the center and become increasingly less dense toward the periphery), one standard deviation (the default value) will encompass approximately 68 percent of all input feature centroids. Two standard deviations will encompass approximately 95 percent of all features, and three standard deviations will cover approximately 99 percent of all feature centroids (Mitchell 2005). The maps below (Figures 22 through 25) illustrate the directional distribution for Odessa, Texas and Provo, Utah.

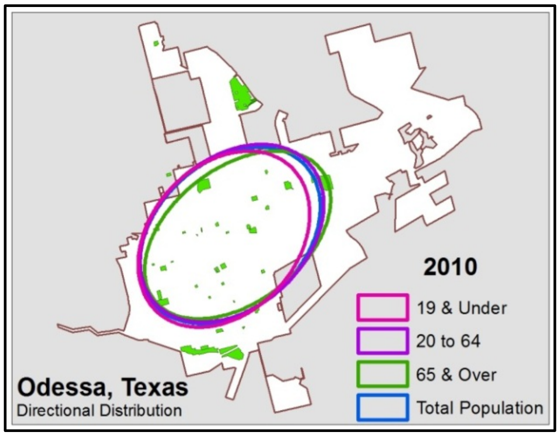

Figure 22. Odessa, Texas
2010 Directional Distribution

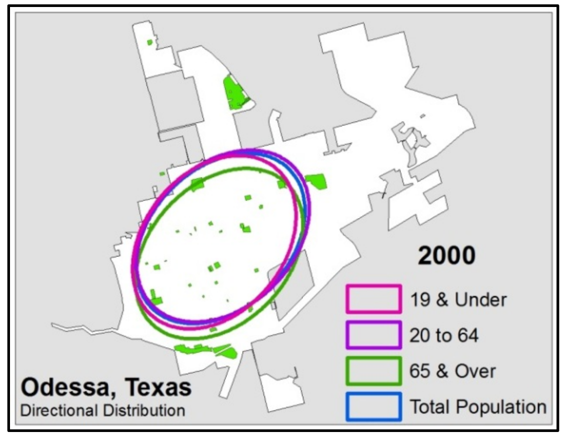

Figure 23. Odessa, Texas
2000 Directional Distribution

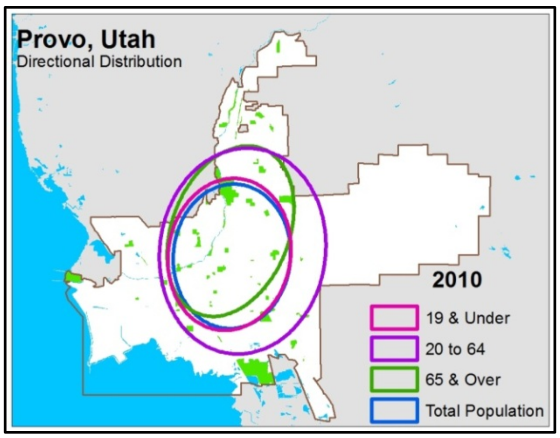

Figure 24. City of Provo, Utah
2010 Directional Distribution

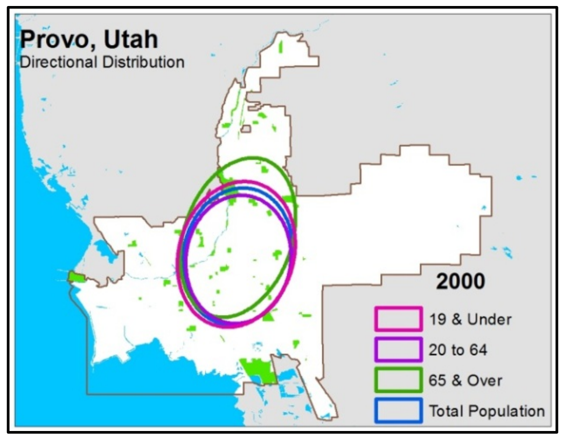

Figure 25. City of Provo, Utah
2000 Directional Distribution

Spatial Autocorrelation

The last analysis method used for this study was Esri's Spatial Autocorrelation (Global Moran's I). Esri defines the Spatial Autocorrelation as a tool that measures spatial autocorrelation based on feature locations and feature values. The result is an evaluation of whether the resulting pattern is clustered, dispersed, or random. The tool calculates the Moran's I Index value and both a z-score and p-value to evaluate the significance of that Index.

The Spatial Autocorrelation tool returns five values:

- Moran's Index
- Expected Index
- Variance
- z-score
- p-value

The spatial autocorrelation tool works by computing the mean and variance for the selected attribute. Then, for each feature value, it subtracts the mean, creating a deviation from the mean. Deviation values for all neighboring features are multiplied together to create a cross-product. The numerator for the Global Moran's I statistic includes these summed cross-products. Suppose features A and B are neighbors, and the mean for all feature values is 10. When values for neighboring features are either both larger than the mean or both smaller than the mean, the cross-product will be positive. When one value is smaller than the mean and the other is larger than the mean, the cross-product will be negative. In all cases, larger deviation from the mean, results in a larger cross-product. If the values in the dataset tend to cluster spatially, the Moran's Index will be positive. When high values tend to be near low values, the Index will be negative. If positive cross-product values balance negative cross-product values, the Index will be near zero. The numerator is normalized by the variance so that Index values fall between -1.0 and +1.0 (Esri 2012).

After calculating the Index value, the Spatial Autocorrelation tool calculates the Expected Index value and compares it to the Observed Index value. Given the number of features in the dataset and the variance for the data values overall, the tool computes a z-score and p-value indicating whether this difference is statistically significant or not. Index values cannot be interpreted directly; they can only be interpreted within the context of the null hypothesis (Esri 2012).

The Spatial Autocorrelation tool is an inferential statistic, meaning that the results of the analysis are always interpreted within the context of its null hypothesis. For the Global Moran's I statistic, the null hypothesis states that the attribute being analyzed is randomly distributed among the features in the study area. When the p-value returned by this tool is statistically significant, you can reject the null hypothesis (Esri 2012). The images below (Figures 26 through 29) illustrate the report provided by the Esri Spatial Autocorrelation tool for Odessa, Texas in 2010.

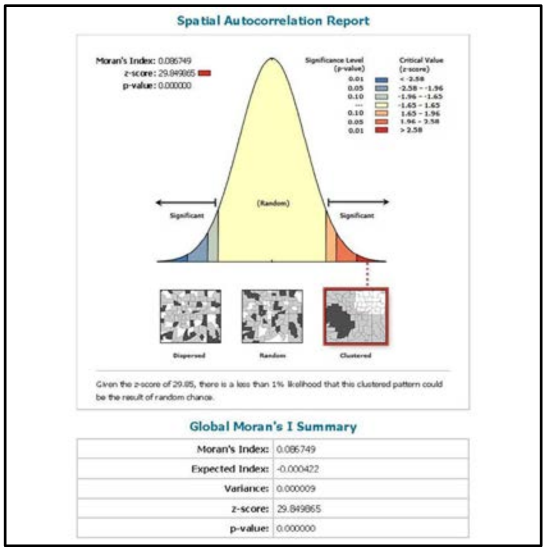

Figure 26. Odessa, Texas
2010 Spatial Autocorrelation
Total Population

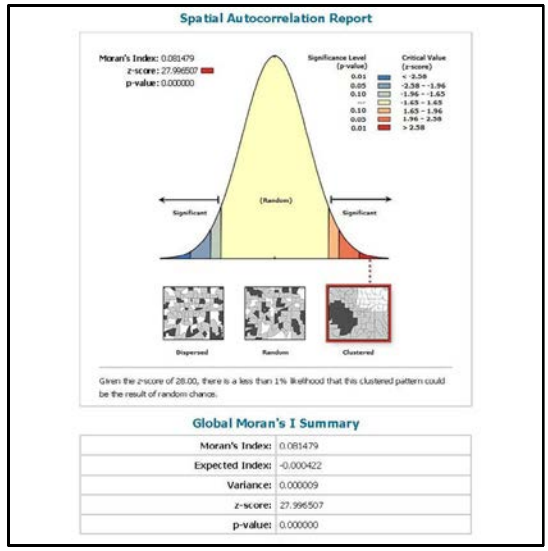

Figure 27. Odessa, Texas
2010 Spatial Autocorrelation
19 & Under

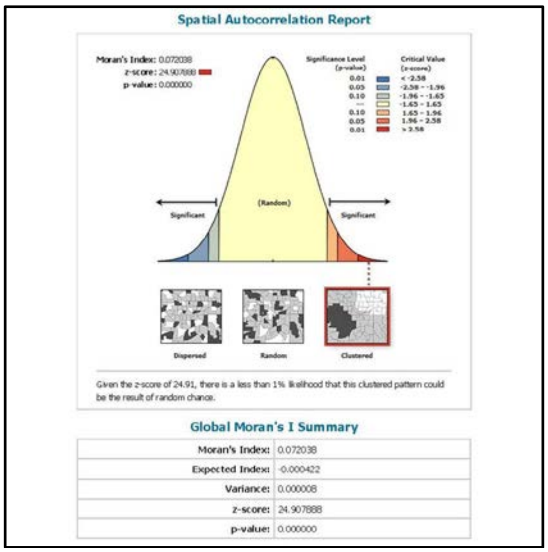

Figure 28. Odessa, Texas
2010 Spatial Autocorrelation
20 to 64

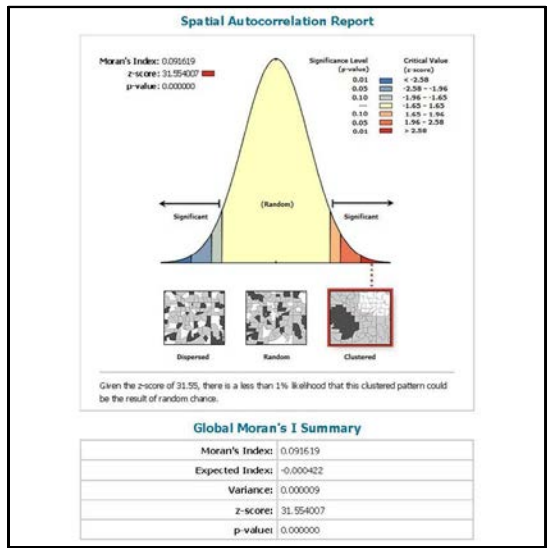

Figure 29. Odessa, Texas
2010 Spatial Autocorrelation
65 & Over

Results

The results of the study are discussed below and are organized based on the general categories outline in the analysis section above. These are: city and green space area, visual patterns, cluster analysis, directional distribution, and spatial autocorrelation.

City and green space area

Calculating the overall area for each city and the green space located within the city's administrative boundaries provided a good overview of the size of each city and how they compare. Provo, Utah is larger than Odessa, Texas in population, but smaller in overall area for both census years, yet a larger percentage of Provo is green space (see table 1 below).

Table 1. Population and area calculations

City	Year	Total Population	Greens Space (Acres)		City Area (Acres)	% of City that is Green Space	Green Space per Person	
			Acres	Sq. Ft			Acres	Sq. Ft
Odessa, Texas	2000	91,702	800	34,848,000	28,530	2.8%	.008	380
	2010	102,121	800	34,848,000	28,530	2.8%	.008	341
Provo, Utah	2000	105,181	917	39,944,520	28,251	3.2%	.009	380
	2010	114,448	917	39,944,520	28,251	3.2%	.008	349

When looking at green space per person in acres, the two cities have similar results. Looking at the square feet per person, Provo shows a slightly larger area per person for both years. Both cities area relatively similar in each area measured, including green space per person and percentage (%) of the city that is green space. This suggests that there may not be a link between a city's geographic location and the amount green space in the city. However, there may be a link between city size and population to green space.

Visual Patterns

The location of green space areas located within the administrative boundary of Odessa, Texas show a fairly even distribution throughout the city except for the eastern portion, where there are very few identified green space areas. Figure 30 below shows the distribution of green space area in Odessa, Texas. Provo, Utah is similar in its distribution of green space area in that there is a fairly even dispersal of green space area throughout the city except for the eastern portion. Figure 31 shows the distribution of green space area in Provo, Utah.

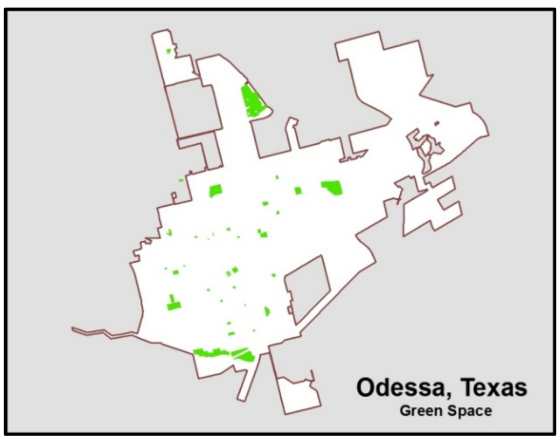

Figure 30. City of Odessa, Texas Green Space

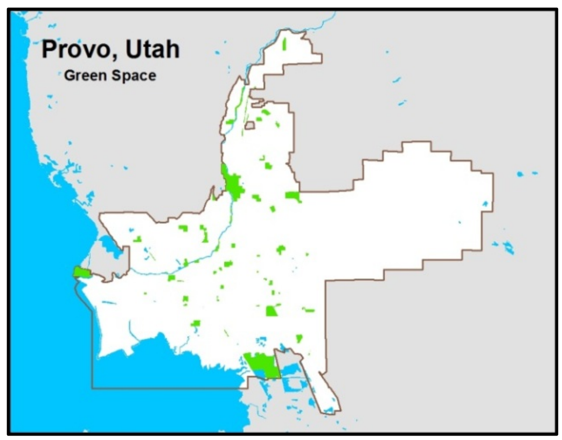

Figure 31. City of Provo, Utah Green Space

Visual analysis of Census datasets for Odessa, Texas depicts an increase in population for all age brackets in the eastern portion of the city when comparing the 2000 and 2010 data. In general, there are dense areas of population, for all age brackets, around the central part of the city. This would suggest growth that is typically expected in a city. The census datasets for Provo, Utah also show an increase in the overall population when comparing 2000 and 2010. There is an increase in population density in the southern and western portions of the city over time and a slight decrease in population in the northern portion of the city.

Cluster Analysis

The first advance statistical analysis performed on the data was a cluster analysis using the Anselin Local Moran's I method. In reviewing the results, a positive value for I indicates that the feature is surrounded by features with similar values. This feature is considered part of a cluster. A negative value for I indicates that the feature is surrounded by features with dissimilar values. This feature would be considered an outlier. The Local Moran's index can only be interpreted within the context of the computed Z score or p-value

Four categories are used to distinguish between statistically significant values in the results of the Anselin Local Moran's I analysis method. They are:

- HH – cluster of high values
- HL – outlier surrounded by low values
- LH – outlier surrounded by high values
- LL – cluster of low values

The following maps (Figures 32 through 39) depict the results of the cluster analysis for Odessa, Texas from the 2010 and 2000 Census.

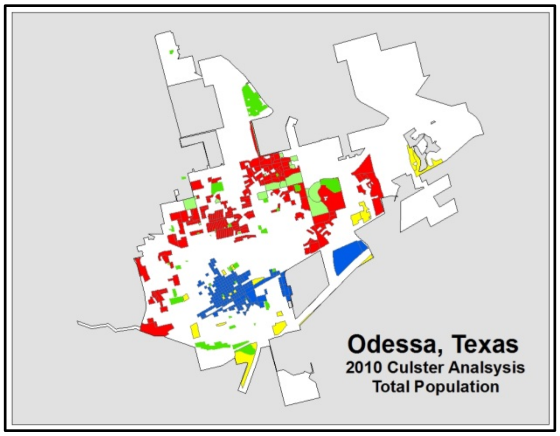

Figure 32. Odessa, Texas
2010 Total Population
Cluster Analysis

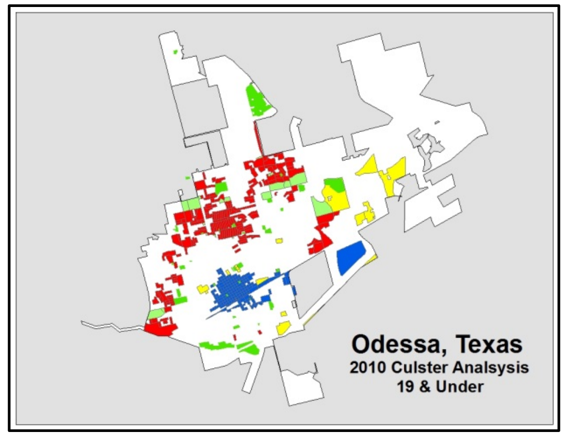

Figure 33. Odessa, Texas
2010 19 & Under Population
Cluster Analysis

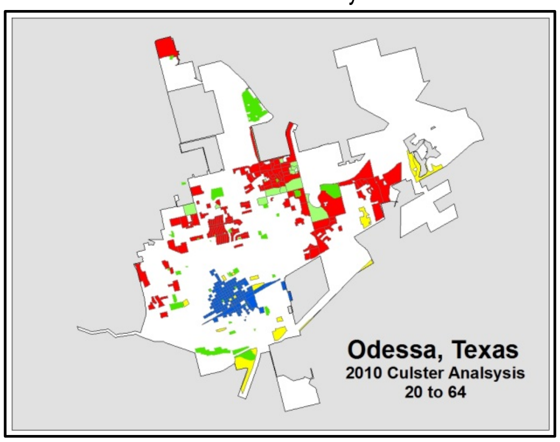

Figure 34. City of Odessa, Texas
2010 20 to 64 Population
Cluster Analysis

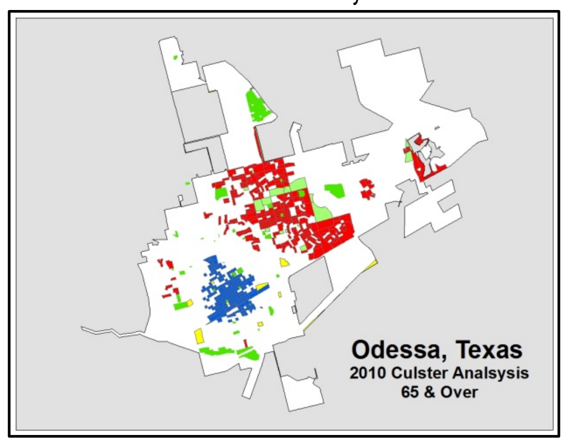

Figure 35. City of Odessa, Texas
2010 65 & Over Population
Cluster Analysis

The 2010 cluster analysis for Odessa, Texas shows a cluster of low values in the southern portion of the city for all age groups. The distribution of high values is fairly similar for the total population, 19 & under, and 20 to 64 age groups. The 65 & Over age group shows a very high concentration in the northern portion of the city.

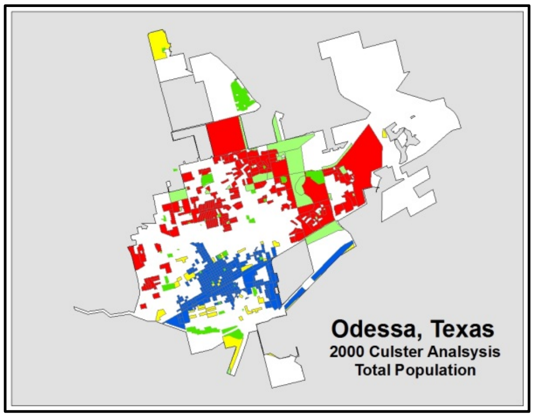

Figure 36. Odessa, Texas
2000 Total Population
Cluster Analysis

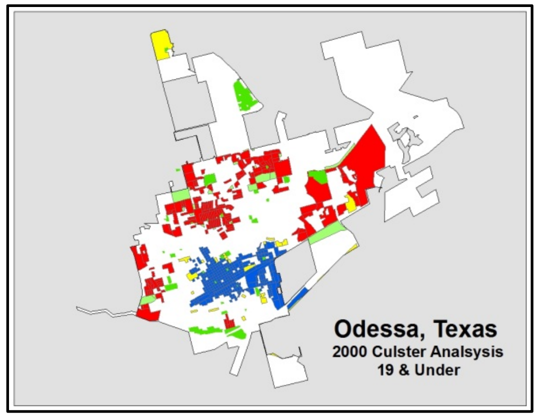

Figure 37. Odessa, Texas
2000 19 & Under Population
Cluster Analysis

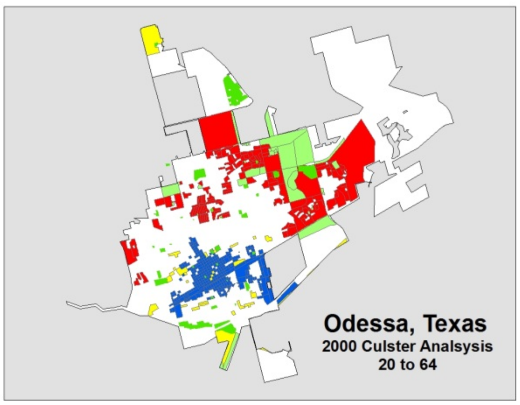

Figure 38. City of Odessa, Texas
2000 20 to 64 Population
Cluster Analysis

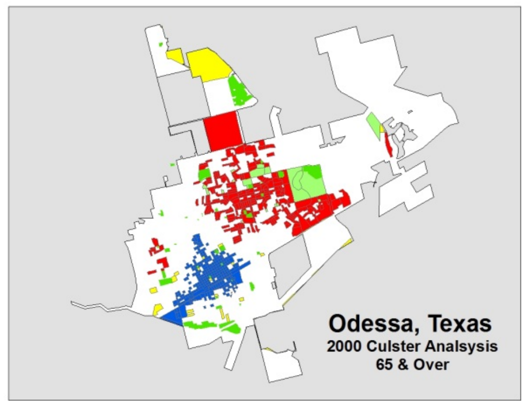

Figure 39. City of Odessa, Texas
2000 65 & Over Population
Cluster Analysis

The 2000 cluster analysis for Odessa, Texas shows a fairly similar distribution of high and low values in all age brackets. There is a smaller amount of distribution noticeable in the 65 & over age group that could be interpreted as the beginning of the clustering found in the 2010 dataset.

The following maps (Figures 40 through 47) depict the results of the cluster analysis for Provo, Utah from the 2010 and 2000 Census.

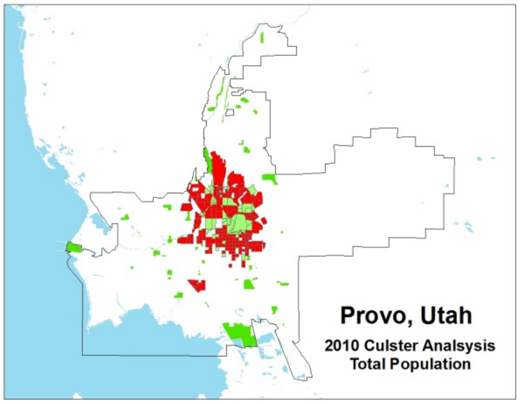

Figure 40. City of Provo, Utah
2010 Total Population
Cluster Analysis

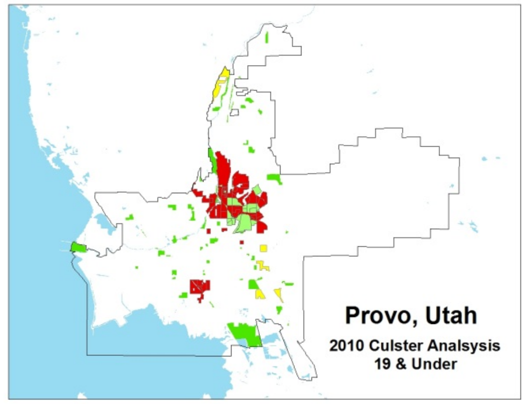

Figure 41. City of Provo, Utah
2010 19 & Under Population
Cluster Analysis

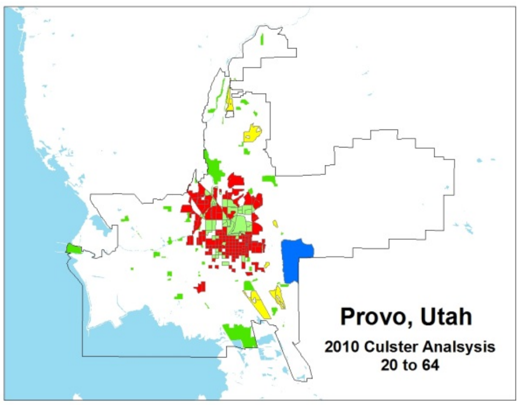

Figure 42. City of Provo, Utah
2010 20 to 64 Population
Cluster Analysis

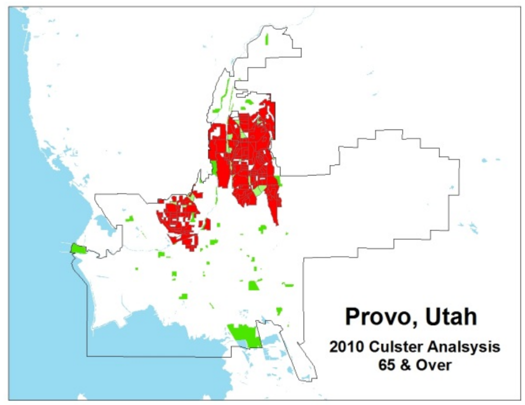

Figure 43. City of Provo, Utah
2010 65 & Over Population
Cluster Analysis

The 2010 cluster analysis for Provo, Utah depicts similar distribution patterns of high values in the central portion of the city for three of the four age groups (total population, 19 & under, and 20 to 64). The 65 & Over age group shows a more concentrated distribution in the northern portion of the city and just to the west of the central portion of the city.

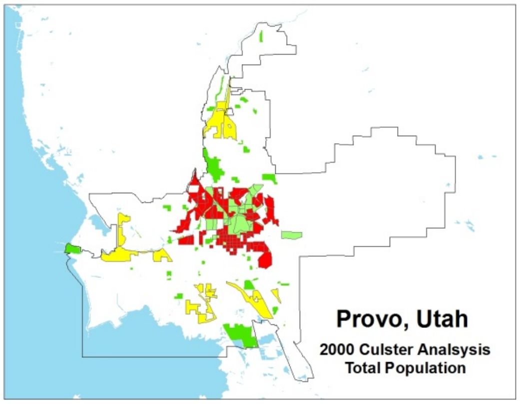

Figure 44. City of Provo, Utah 2000 Total Population Cluster Analysis

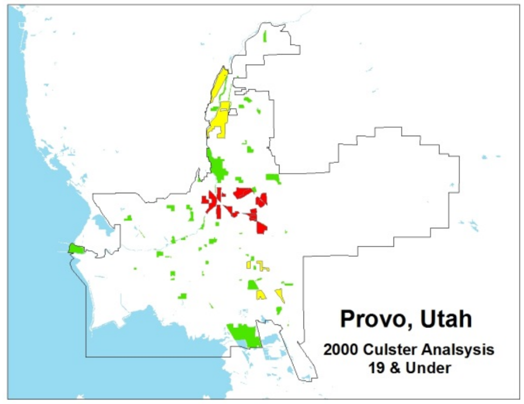

Figure 45. City of Provo, Utah 2000 19 & Under Population Cluster Analysis

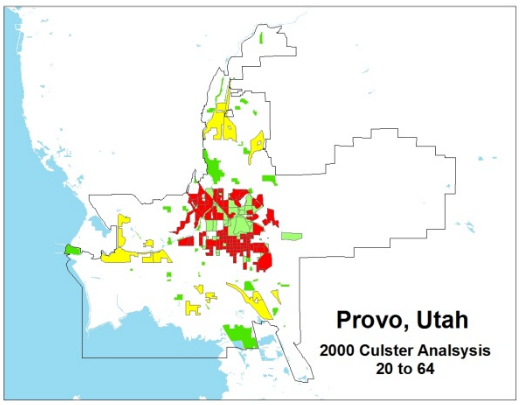

Figure 46. City of Provo, Utah 2000 20 to 64 Population Cluster Analysis

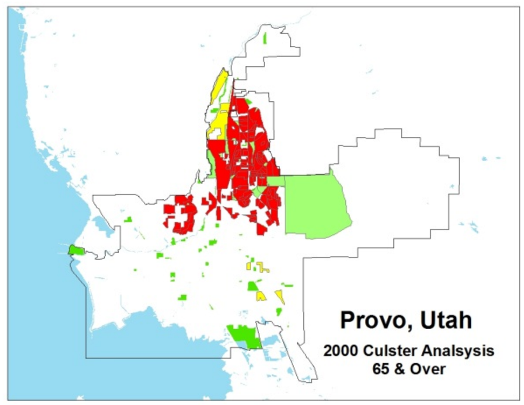

Figure 47. City of Provo, Utah 2000 – 65 & Over Population Cluster Analysis

The 2000 cluster analysis for Provo, Utah depicts similar distribution areas for high values in the total and 20 to 64 age groups. The high values for the19 & under age group have a very small distribution area in the center of the city, which changes drastically when compared to the 2010 19& under results. The 65 & over age group has a large concentration of high values in the northern portion of the city that does not change much in the 2010 results.

Directional Distribution

Analysis for the standard deviational ellipses for Odessa, Texas in 2000 show a northeast to southwest trend for all four age groups (Total population, 19 & under, 20 to 64, and 65 & over). The standard deviational ellipses in 2010 (Figure 48) for Odessa, Texas show similar trends, indicating no major changes in population distribution. The 20 to 64 age group does very slightly from the other three age groups in that it appears to cover a larger area, but shows a similar northeast to southwest trend. Looking at the data for Provo, Utah, the trend for all age brackets in the 2000 dataset is almost identical running north-northeast by south-southwest. When compared to the green space area, a relationship between the population distribution and green space area is possible. The eastern portion of Provo has very few identified green space areas, while the Northern, Southern, and central portions of the city have a significant number of green space areas. While the ellipses show a trend of northern movement away from the city's largest green space area, there are a significant number of green space areas in the northern portion of the city. The total population and 19 & under datasets produced results that were very similar to the 2000 ellipses. The 65 & over dataset produced a stronger trend toward the northern portion of the city, while the 20 to 64 dataset displayed a much broader area of movement (Figure 48). Comparing the ellipses for all age brackets and both years to green space produced results that would indicate that there is not relationship between population location and green space.

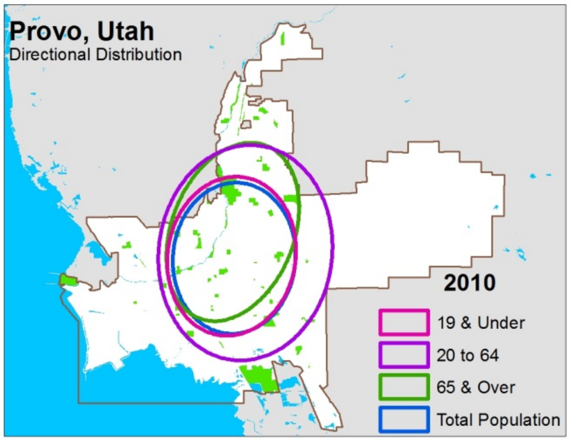

Figure 48. City of Provo, Utah 2010 Directional Distribution

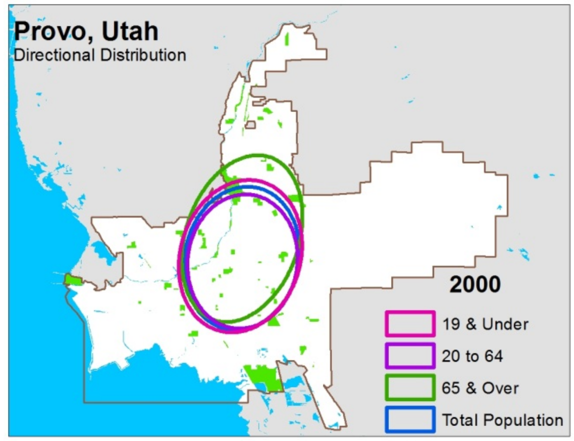

Figure 49. City of Provo, Utah 2000 Directional Distribution

Spatial Autocorrelation

The results of analysis using spatial autocorrelation show high Z-score (lowest Z-score is 11.608, highest Z-score is 43.315) for all datasets which means that they are statistically significant and that null hypothesis is rejected for all datasets. Because of the significance of the Z-score value, there is less than 1% chance that the results are due to random chance. Additionally, the Moran's Index value is positive and greater than zero for all datasets indicating clustering in all datasets. Tables 2 through 5 (below) show the spatial autocorrelation for Odessa, Texas and Provo, Utah for the census years 2010 and 2000.

Table 2. City of Odessa, Texas - 2010

Spatial Autocorrelation	Odessa, Texas 2010			
	Total Population	19 & Under	20 to 64	65 & Over
Moran's Index	0.086749	0.081479	0.072038	0.091619
Expected Index	-0.000422	-0.000422	-0.000422	-0.000422
Variance	0.000009	0.000009	0.000008	0.000009
z-score	29.849865	27.996507	24.907888	31.554007
p-value	0.000000	0.000000	0.000000	0.000000

Table 3. City of Odessa, Texas - 2000

Spatial Autocorrelation	Odessa, Texas 2000			
	Total Population	**19 & Under**	**20 to 64**	**65 & Over**
Moran's Index	0.102780	0.092334	0.088739	0.083807
Expected Index	-0.000480	-0.000480	-0.000480	-0.000480
Variance	0.000006	0.000006	0.000006	0.000006
z-score	43.315291	38.911932	37.607145	35.662237
p-value	0.000000	0.000000	0.000000	0.000000

Table 4. City of Provo, Utah - 2010

Spatial Autocorrelation	Provo, Utah 2010			
	Total Population	**19 & Under**	**20 to 64**	**65 & Over**
Moran's Index	0.141166	0.106429	0.147794	0.102438
Expected Index	-0.000562	-0.000562	-0.000562	-0.000562
Variance	0.000016	0.000014	0.000016	0.000016
z-score	35.306543	28.431456	37.026935	25.812174
p-value	0.000000	0.000000	0.000000	0.000000

Table 5. City of Provo, Utah – 2000

Spatial Autocorrelation	Provo, Utah 2000			
	Total Population	**19 & Under**	**20 to 64**	**65 & Over**
Moran's Index	0.075456	0.036790	0.109433	0.076603
Expected Index	-0.000874	-0.000874	-0.000874	-0.000874
Variance	0.000012	0.000011	0.000012	0.000012
z-score	22.103897	11.608251	31.827874	22.358976
p-value	0.000000	0.000000	0.000000	0.000000

Discussion

This study examined whether there is a spatial relationship between green space and age within a city's population. We began by investigating the relation between green space, city area and city demographics. Next, we then performed a series of spatial and statistical analysis on the demographic data in relation to green space. This study shows that the green space area per person is relatively close for each city (.008 and .009 acres per person). This was unexpected given the geographic location of each city (Odessa in the south, and Provo in the north), as well as the economic strengths of each city.

Advanced analysis of the data provided more insight into the population distribution for each city. Each city had an area of dense population that is consistent with the typical makeup of larger cities. Unexpectedly, there was a much smaller variation in population distribution than was anticipated when looking at the age groups individually. The age group that displayed the most variation from the average or total population was the 65 & Over age group. Interestingly, the 65 & Over age group showed more signs of clustering in a single area rather than being dispersed throughout each city.

An interesting variable not measured in this study that would directly impact census statistics would be the availability of housing near green space areas. While most individuals would prefer a shorter distance to green space, there may not be adequate or available housing to move to (Hornsten 2000). Another factor to consider that is difficult to measure scientifically is the perception individuals have regarding their health and proximity to green space (Sharp 2007). Home (2009) has conducted a study that begins to look at human perception and has attempted to quantify whether this is a cultural or an inherently human characteristic.

Overall, the results of all the analysis performed on the data proved to be inconclusive. Establishing a causal relationship between green spaces and health is difficult (Maheswaran 2010), there were no obvious trends or relationships between green space and each city's population. The general area and green space per person calculations show very little change in each city's composition. The cluster analysis (Anselin Local Moran's I) displayed significant clustering, but not near green space for all age groups. As mentioned in the results section, there was a noticeably different clustering by the 65 & over age group. Kaczynksi (2007) suggests this could be due to the location of golf courses, but no golf courses were located within city's administrative boundary near the cluster areas. Surprisingly, there did not appear to be a distinct clustering by the 19 & under age group. The directional distribution analysis (standard deviational ellipse) provided little insight into whether population and age group movement was towards or away from green space. Spatial autocorrelation provided statistically significant results, but again could not be definitively related to green space.

Limitations

In organizing and conducting this study, it became evident that there were a number of factors that would limit the results. The first issue identified was that limit or lack of resources. Because of the limited resources available for this study, the green space data set is not as comprehensive as it could be. With additional resources, data should be collected for any area(s) that fit the definition of green space (grass, trees, plants, field, parks, medians, etc.). Collecting green space data at that scale would require a large team and significant effort to plan, collect, and attribute data for an entire city.

The Number of study areas (cities) used in this city could arguably be considered to be too small of a sample to provide conclusive results. A larger sample size of 10 cities would provide a more statistically sound sampling of cities in the United States.

Another issue that should be considered in future studies is that the city administrative boundaries used to determine what data is included in each dataset may not contain all relevant green space areas. Both Odessa, Texas and Provo, Utah have parks, golf courses and other green space areas located outside of the city administrative boundary. Some of these green space areas were significant in size and would have altered the results of analysis performed on the data.

Census data provides a very great resource to analyze demographic data across the United States. Because of privacy concerns and the time involved in acquiring and preparing the data, the U.S. Census Bureau does not information on individuals. Census data is grouped at different scales to protect privacy, aggregate data, and keep data collection and processing costs manageable.

Census data is collected for many different age groups, providing a very good resource for analyzing demographics by age, gender, and race. The scope of this study did not allow for the analysis of all of the age groups accounted for in the census data. Grouping the various age groups into three broad ranges (child (19 & under), adult (20 to 64), and senior (65 & Over)) was necessary in order to analyze the data. Because the census data has been generalized, the possibility of overgeneralization exists and some trends may be hidden and overlooked, skewing the results of the study. With further analysis, there may be a more appropriate number of groups and division of the age groups.

Finally, historical GIS records were either not kept or not available for either city, making it impossible to accurately reflect the city boundary and green space area for the year 2000. Without an accurate picture of each city during the 2000 census, it is difficult to look at the results of any analysis without questioning their accuracy. City growth and the additional or removal of green space would alter the outcome of the analysis.

Further Research

The findings in this study establish a baseline for determining if there is a spatial relationship between age and green space. With this established, studies can begin to determine if a single or multiple factors are contributing to this relationship in a positive or negative manner. Because of the relatively small amount of research conducted in this area, and the number of disciplines that have considered this topic, a coordinated effort should be developed in future research to account for the multitude of variables. Future studies need to be a collaborative effort between health professionals, psychologists, sociologists, planners, and sociologists.

Currently, there is more research on the psychological and social effects of green space than there are in any of the other areas. Few studies have investigated the relationship between social contacts and green space (Kuo (1998)). Hernandez (2005) has shown a benefit to green space simply by being shown a photo of natural elements. Analyzing this further could bring about new theories on billboard use or utilizing pictures of green space in key locations.

Future research in the medical field can focus on measurable benefits or the lack of any benefits as it relates to green space. Hill (2003) shows us that greening of urban areas could make a contribution to increase physical activity, which leads to better health. Additionally, living environments with close proximity (1km) to green space experience lower rates of disease (Mass (2009)). Most studies show that green space has a positive impact on human health, but need to be researched further.

Future studies in the environmental field can look at the different combinations of green space and variation on how it can be applied. Some areas of interest might be types of vegetation and the effect on human health and life expectancy, open green space (grass fields) compared to closed in green space (wooded area), the role gardens play in improving human health, and small-scale green space (trees along streets and yards) (van den Berg (2010). There are few articles providing information about the specific landscape elements that can make a difference in terms of health effects (Verlarde (2007)). Additional research needs to be conducted to begin identifying key components of green space areas that have a positive or negative impact on human health.

Economic issues could also have an impact on green space and how a city views them. Economic class levels will also impact where people live and where city resources are ~~disctibuted~~ distributed (Taylor 1998). Research on the role the economy plays in the city's decision to maintain, add, or subtract green space could play a significant role in determining the value a city puts on green space.

Finally, one exciting possibility for future research would be around the impact of moving green space from the traditional place of a field or wooded area to an urban location like the top of a building or integrating it in a building (similar to an atrium).

Conclusion

At the beginning of this study, a clear goal was defined to identify a potential relationship between green space and age. Through research and analysis presented in this study, many variables were identified that could have a significant impact on this study. While the goal did not change, it has become clear that the question of whether there is a relationship between green space and age is a very complex one. Local park and recreation areas provide a space for people to escape from routine and to be close to nature (Ho 2003). From this study, no clear spatial relationship was established, but it is evident that there are many factors that can impact this potential relationship. It is the intent of this study to provide a baseline which will allow further research and hopefully a spark to initiate more in depth study into this area. Researching each variable independently can and will provide valuable input into the overall potential relationship between green space and age. Ultimately, a combination of efforts across multiple disciplines and input from the much needed research on the independent variables and landscape types (Verlarde 2007) will be needed to comprehensively measure and determine if there is a relationship between green space and age.

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